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RADIO PROPERTIES OF NARROW-LINED SEYFERT 1 GALAXIES

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ABSTRACT

We have observed seven narrow-lined Seyfert 1 (NLS1) galaxies and one high-ionization Seyfert 2 galaxy with the VLA. Combining these observations with published data, we summarize the radio properties of the NLS1 galaxies for which spectropolarimetry was reported in 1989 by Goodrich (ApJ, 342, 224). Fifteen of these 17 objects now have published radio observations of high sensitivity, and only nine of those have been detected. For a Hubble parameter of 75 km s^{-1} Mpc^{-1}, the 6-cm radio powers range from 10^{20} to 10^{23} W Hz^{-1}, within the range previously found for other types of Seyfert galaxy. The median radio size of the nine VLA-detected galaxies is no larger than 260 pc, similar to the median size found by Ulvestad & Wilson (1989, ApJ, 343, 659) for a distance-limited sample of Seyfert galaxies. Of the six NLS1 galaxies known to have significant intrinsic optical polarization, three have measurable radio axes. Two of those three galaxies have radio major axes close to 90° from their polarization position angles, while the third has an inner radio axis that may be nearly parallel to the polarization position angle.

1. INTRODUCTION

Seyfert galaxies were subdivided into types 1 and 2 twenty years ago (Khachikian & Weedman 1974), a classification scheme that has served astronomers well in attempting to determine the nature of these galaxies. The original classification into two types was based almost entirely on the relative widths of the strong emission lines. In the Seyfert 1 galaxies, the permitted lines have strong components with widths on the order of 10,000 km s^{-1}; they also may have weaker components with widths on the order of 500 km s^{-1}, as do the forbidden emission lines (such as [O III]). Both permitted and forbidden lines have similar widths of 500 km s^{-1} in Seyfert 2 galaxies. Intermediate Seyfert classifications ranging from 1.2 to 1.9 have been created over the years (e.g., Osterbrock & Koski 1976; Osterbrock 1981; Cohen 1983), and some Seyfert galaxies have changed their classifications on time scales of weeks to months, usually within the various intermediate Seyfert classifications (e.g., Cohen *et al.* 1986).

It was long believed that the nuclei of Seyfert 2 galaxies have radio sources that are systematically more powerful and larger than those in Seyfert 1 galaxies, with Seyfert 1.2 through 1.9 galaxies being intermediate in radio properties (de Bruyn & Wilson 1978; Meurs 1982; Meurs & Wilson 1984; Ulvestad & Wilson 1984a,b; Ulvestad 1986). Edelson (1987) contended that the radio luminosities of Seyfert 1 and 2 galaxies are similar for an optical-magnitude-limited sample, although he had insufficient resolution to separate nuclear and disk radio emission. Ulvestad & Wilson (1989) showed that the apparently higher nuclear radio luminosity and size of the Seyfert 2 galaxies might be accounted for by selection effects; when the weaker Seyferts (mostly Seyfert 2 galaxies) found in surveys of nearby galaxies are included and radio-source sizes are compared at equivalent dynamic ranges, the differences in radio powers and sizes are no longer statistically significant. A contemporaneous study by Giuricin *et al.* (1990), based on a sample of bright, spectroscopically selected Seyferts, also concluded that the radio sources in the different Seyfert types are not significantly different. A recent summary of the radio properties of Seyfert galaxies can be found in Wilson (1991).

Antonucci (1983) made tile interesting observation that the Seyfert 1 galaxies tend to have optical continuum polarization parallel to their radio major axes, while Seyfert 2 galaxies have perpendicular polarization. This has been interpreted as a difference between thin and thick scattering disks (Antonucci 1984). The remarkable result that NGC 1068, the archetypal Seyfert 2 galaxy, shows very broad permitted line emission in polarized light (Antonucci & Miller 1985) indicates that at least some of the difference between Seyfert 1 and Seyfert 2 galaxies might be merely an orientation effect; a similar suggestion, based on X-ray properties of the galaxies, was made by Lawrence & Elvis (1982). Since the original discovery in NGC 1068, a number of other Seyfert 2 galaxies also have been shown to display broad permitted lines in polarized light (Miller & Goodrich 1990), supporting the intrinsic similarity of Seyfert 1 and Seyfert 2 galaxies. Orientation clearly is not the whole story, as described in a more detailed summary of unified schemes for Seyfert galaxies (Antonucci 1993).

Yet another class of Seyfert galaxies was proposed by Osterbrock & Pogge (1985), the "narrow-lined Seyfert 1 galaxies" (hereafter N LS 1 galaxies]. These objects have permitted line widths much smaller than typical Seyfert 1 galaxies, on the order of 1,000 km s^{-1}. However, they differ from Seyfert 2 galaxies in that their optical spectra show several characteristics normally associated with Seyfert 1 galaxies, such as [0 111]/11/3 ratios of less than 3, permitted lines somewhat broader than the forbidden lines, and either blends of Fe 11 emission or very high excitation emission lines such as [Fe VII] or [Fe X]. About 10% of Seyfert 1 galaxies may be NLS1 galaxies (Stephens 1989). An extensive optical spectropolarimetric study of these objects was carried out by Goodrich (1989) in order to determine their properties and their relation to other types of Seyfert galaxies. He observed a total of 18 objects, including one high-ionization Seyfert 2 galaxy. Six of the NLS1 galaxies were found to show significant intrinsic polarizations. Goodrich (1989) concluded that the NLS1 galaxies fall on a continuum with Seyfert 1 galaxies in their emission-line properties, and show optical polarization caused by dust that may be associated with the narrow-line regions, One possible explanation for the narrowness of the permitted lines in NLS1 objects might be that the gas motions in the broad-line region are con fined to an accretion disk viewed nearly pole-oll.

We have made new VLA[1] observations of a number of NLS1 galaxies in an effort to relate them to the other types of Seyfert galaxies and provide additional data for determining whether their properties are determined largely by orientation or by intrinsic differences from other Seyferts. Of particular interest are the typical sizes of the radio sources, which might be expected to be quite small if the accretion disks are viewed in a polar direction, and the relation between the radio axes and the optical polarization position angles. Goodrich (1989) reports optical polarization position angles nearly perpendicular to the radio major axes in two NLS1 galaxies, and more such examples have hewn sought with the additional VLA observations. This paper reports the results of the new VLA observations and briefly compares the radio properties of the NLS1 galaxies to other Seyfert galaxies.

[1]The VLA is a facility of the National Radio Astronomy observatory, which is operated by Associated Universities, Inc. under a coop erative agreement with the National Science Foundation.

2. OBSERVATIONS AND DATA REDUCTION

The VLA observations made use of the highest resolution (A) configuration in order to probe the radio-source position angles of the NLS1 galaxies at the smallest scale. Program objects were selected from those studied by Goodrich (1989), with preference given to the galaxies that appeared to show significant intrinsic optical polarization. Observations of 10 objects, mostly at wavelengths of 6 and 20 cm but with one source also observed at 2 cm, were scheduled for two sessions on 1987 July 31 and August 1. Unfortunately, a power failure at the VLA eliminated the first session and two program objects. The second session, eight hours in duration, included observations of eight galaxies, but the continuing effects of the power failure caused these observations to be made without the North arm of the VLA. Therefore, a maximum of 18 antennas was available, and beam shapes were particularly asymmetric for the southernmost sources.

Data also were acquired at 3.6 cm on 1991 July 15, consisting of observations of three galaxies that were detected as relatively strong radio sources in 1987, but showed no clear resolution at 6 or 20 cm. These observations also were made in the A configuration, and 26 antennas were available. Table 1 summarizes all the observations, giving dates, wavelengths, approximate times on source, and beam sizes for each galaxy.

All data were acquired using two adjacent 50-MHz bandwidths, providing a total bandwidth of 100 MHz at each wavelength. For each target, a point calibration source near the galaxy was observed for phase calibration, and all flux densities were referred to standard values for 3C 286. Because of the snapshot nature of the observations, no effort was made to calibrate radio polarization. Table 2 gives the central frequency in each waveband and the assumed flux density for 3C 286 at each frequency. The data were calibrated in the standard way by applying the antenna gains determined for the local calibration sources to the program galaxies. The weather during the 1987 observations was terrible, and rapid phase variations affected the data calibration substantially. In some cam, weak source detections were improved by self-calil)ratillg the data using standard routines in the Astronomical Image Processing System (A II'S). At 6 and 20 cm, it was possible to use long integration times to achieve adequate signal-to-noise for self-calibration, but this was not possible at 2 cm because of the larger phase variations at the shorter wavelength. Thunderstorms during the 3.6-cm observations in 1991 caused short data outages and rapid phase fluctuations, but self-calibration enabled reasonable recovery of antenna phases. It is possible that the upper limits on the two sources not detected at 6 cm should be increased clue to the poor weather, and the non-detection of the single source observed at 2 cm probably was weather related.

Maps were made in each of the two 50- MHz bands at each wavelength, then averaged to give the final images. For the two galaxies not detected in the full-resolution images at 6 cm, lower resolution maps (weighting the short baselines more heavily) covering areas four arcminutes on a side were made to attempt source detection. in several cases, particularly at 20 cm, fairly wide field maps were made in order to eliminate confusing sources. Typical noise levels in tile final full-resolution maps were 100 μJy at 3.6 and 6 cm and 200 μJy at 20 cm. No noise can be quoted for the 2-cm observation because the weather made the data unusable.

3. RESULTS FOR INDIVIDUAL GALAXIES

Most of the galaxies observed in this program were detected, with flux densities at the various wavelengths ranging from less than a millijansky to over 50 mJy. One noteworthy result is that the only convincing evidence for resolution in any of the newly observed radio sources is in Mrk 766. Upper limits on tile sizes of most other sources at 3.6 and 6 cm are 0".2- 0".4. Assuming a Hubble parameter of 75 km s^{-1} Mpc^{-1}, as we do throughout the remainder of this paper, such size limits correspond to linear sizes of 75-400 pc at redshifts of $z \approx$ 0.02-0,05.

Table 3 summarizes the observational results. For each galaxy, redshifts, positions (B1950) derived from the VLA images, and flux densities are listed, together with radio powers and linear sizes. The upper limits to the sizes are taken to be equal to the average of the diameters of the beam major and minor axes. Smaller limits might be placed on the sizes of the strongest sources, for which the signal-to-noise ratio is high enough to detect resolution smaller than the actual beam size. Therefore, the size upper limits arc, in general, fairly conservative estimates.

For galaxies that were not detected, the position given in Table 3 is the center of the field observed. All galaxy positions were known in advance with accuracies of a few arcseconds or better, so the low-resolution maps of the fields of the undetected galaxies were large enough to detect any emission from the target objects. Upper limits of three times the r.m.s. fluctuations in the High-resolution images are quoted in Table 3.]lux-density errors for each detected source have been estimated by combining (in quadrature) the r.m s. noise in blank areas of the final map, the error in the Gaussian fit to the source flux density, and an assumed scale error of 5% at all wavelengths. The larger-than-normal assumed scale error is a, consequence of the poor weather, the lack of one arm of the VLA during the 6- and 20-cm observations, and experience gained during other VLA observations in which two of us were exposed to the large errors that sometimes can be made in the VI, A flux-density scale (Ulvestad & Antonucci 1994). Comments on tile individual galaxies are given below; al' optical polarization data mentioned are from Goodrich (1989).

Mrk 42. The new upper limit of 0.25 mJy at 6 cm is consistent with the 21 cm upper li it of 4 mJy found at Westerbork by de Bruyn & Wilson (1976). The pointing position was taken from the position of the optical nucleus measured by Clements (1981), which has an accuracy of 0".2. The optical polarization of this object is less than 0.5% and may not be intrinsic to the Seyfert galaxy.

Mrk 493. The weak radio source, with a strength of 0.77 mJy at 6 cm, appears completely unresolved, with an upper limit of 150 pc to the source diameter. The optical polarization is only 0.26% and may be caused by dust within the Galaxy.

Mrk 507. Only 20-cm data were acquired because the Westerbork upper limit of 3 mJy at 21 cm, previously published by Wilson & Meurs (1 982), made it unlikely that a radio position angle could be found at G cm. The weak detection of 3.21 mJy is marginally consistent with the Westerbork upper limit. The source position is approximately 0".9 from the optical position given by Clements (1983), in a direction consistent with the supposition that his position may have hewn affected by the foreground G star reported by Halpern & Oke (1987) to be 2".0 away. The radio source appears unresolved, although the large beam at 20 cm leads to the rather large upper limit of 1.2 kpc for the source sire. This galaxy shows apparently intrinsic optical polarization of 0.61% at a position angle of 12°, roughly parallel to the direction to a companion galaxy located 36" to the south (Halpern & Oke 1987).

Mrk 684. This galaxy has a G-cm upper limit of 0.25 mJy at 6 cm. The optical position has an accuracy of only 5" (Kojoian, Elliott, & Tovmassian 1978). In a 4-arcminute field centered 011 the position listed in Table 3, the only source detected was a 1.7-mJy source located at (14^h 28''' $50^s.08$, 4 28 °31'24''.0), more than an arcminute from the nominal position. Unless the errors on the optical position were tremendously underestimated, this source is unrelated to the nucleus of Mrk 684, The optical polarization of the galaxy is less than 0.2%.

Mrk 766 (NGC 4253). This rather nearby galaxy (z = 0.0121) has been observed with radio interferometers several times in the past. A G-cm image was published by Ulvestad & Wilson (1 984a), with apparent slight resolution in a roughly north-south direction. Detections at 20 cm have been made at Westerbork (Wilson & Meurs 1982) and at the VLA (Ulvestad & Wilson 1989). We re-observed the galaxy at 6-cm with the VLA in an effort to confirm the position angle published by Ulvestad & Wilson (1 984a). The flux density of 11.7 mJy is somewhat lower than the value of 15 mJy published previously. (Self-calibration with a long averaging time seemed effective in correcting the phases for bad weather.) Observations at 2 cm on the same date revealed no source, even when self-calibration was attempted by using a model of a point source at the 6-cm position. Since, these 2-cm observations were affected greatly by the poor weather, no results are listed in ~'able 3.

A Gaussian fit to the 6-cm image gives a source size of 0".26 x 0".19 in position angle 12° ± 5°. This is consistent, within the errors, with the position angle of 16° derived by Ulvestad & Wilson (1984a), while the linear size of 60 pc also is consistent with the value found by those authors. In order to attempt to confirm the position angle, a higher resolution observation at 3.6 cm was made in 1991. The resultant image, shown in Figure 1, clearly is resolved, with a Gaussian fit giving a size of 0",25 x () ".15 in position angle 22°44°. in addition, there may be another component slightly farther out to the northwest, in position angle -30°. (This possible division into several components also is consistent with an unpublished, 2-cm VLA observation made by Ulvestad & Wilson.) The total flux densities at 3.6 cm and 6 cm yield a spectral index of $\alpha = 0.86 \pm 0.13$ ($\alpha = -d \log S_\nu / d \log \nu$). Mrk 766 has strong optical continuum polarization of 2.34% in position angle 90°, 70°-80° from the position angle of the innermost radio axis.

Mrk 1239. This galaxy is another object with high optical polarization, 3.35% in position angle 130°. Mrk 1239 was found to be a relatively strong radio source, with a flux density of over .50 mJy at 20 cm and nearly 20 mJy at 6 cm. Since the source is unresolved at both 6 cm and 20 cm, a 3.6-cm observation was obtained in 1991 to try to obtain a position angle for comparison with the optical polarization. However, even at 3.6 cm, the source remains unresolved, with a size upper limit of 80 pc. The apparent spectral index between 3.6 and 6 cm is α = 1.64+ 0.11, much steeper than the spectral index of 0.9040.06 between 6 and 20 cm. An alternative explanation to spectral steepening is that the source decreased in flux density somewhat between the 1987 and 1991 observations.

Mrk 1388. Mrk 1388 contains a fairly weak radio source that is unresolved at both 6 cm and 20 cm. The flux densities of 3.5 mJy at 6 c.in and 9.1 mJy at '20 cm yield a spectral index of 0.80 ± 0.08. Strong optical polarization of 0.90% exists in posit ion angle 78°, but there is no measurable radio position angle for comparison. Osterbrock (1985) and Goodrich (1 989) state that this object is more properly classified as a Seyfert 2 galaxy with high ionization, so it is not included in the global summary of NLS1 properties later in the present paper.

IRAS 1509- 211. This IRAS galaxy has the strongest optical polarization of the NLS1 objects, 4.61% in position angle 62°. It also is the most powerful radio source of those observed in this program; its 20-cm flux density of 42.6 mJy corresponds to a radio power above 10^{23} W Hz^{-1}. Since IRAS 1509-211 is located at a southern declination, the lack of the north arm of the VLA during the 6- and 20-cm observations caused a beam major/minor axis ratio of more than 6:1 at both wavelengths. A later 3.6-cm observation also was acquired in an effort to find a radio position angle. Gaussian fits to the 3.6-cm source in the full-resolution and slightly tapered maps reveal some evidence for resolution, but these fits still arc consistent with the radio source being unresolved, giving an upper limit of 210 pc for the diameter. The spectrum is straight between 3.6 and 20 cm, with a spectral index of 1.053 0.04.

4. DISCUSSION

Of the 18 galaxies for which Goodrich (1989) reported optical spectropolarimetry, VLA observations of eight are reported in the present paper, while observations of two more (Mrk 359 and Mrk 1044) were destroyed by the VLA power failure. Five of the seven galaxies having significant intrinsic optical polarization (six NLS1 galaxies and one high-ionization Seyfert 2) were imaged; those galaxies are Mrk 507, Mrk 766, Mrk 1239, Mrk 1388, and IRAS 1509– 211. A sixth intrinsically polarized galaxy, Mrk 1126 (NGC 7450), was mapped with the VLA by Ulvestad & Wilson (1984b). The seventh significantly polarized object, Mrk 957, was not observed because its optical polarization was not known until spectropolarimetry was obtained several weeks after the initial VLA observations (Goodrich 1989). Coincidentally, and fortunately, Mrk 957 (as 5C 3.100) was observed at the VLA in 1981 by one of us as part of another project (Antonucci 1985). That map revealed a peak flux density of 1.46 mJy at 4760 MHz. The detection is inconsistent with the upper limit of 0.6 mJy found by Stine (1992) from 1987 VLA observations with similar resolution, leading to the inference that the radio source has varied or that the published upper limit is incorrect.

With the observations published here, a set of high-resolution and nigh-sensitivity radio data exists for all seven significantly polarized galaxies discussed by Goodrich (1989). Three more weakly polarized (or unpolarized) galaxies were observed in the present program, and high-resolution VLA observations of Akn 564 (Ulvestad, Wilson, & Sramek 1981), Mrk 783 (Ulvestad & Wilson 1984a), and 1747.3+6836 (Hutchings & Gower 1985) also have been published previously. After eliminating Mrk 1388 because it is better classified as a type 2 Seyfert, 12 of 17 NLS1 galaxies have VLA observations at arcsecond resolution. Three others have been observed with interferometers or single dishes, while no radio data have been published on the final two galaxies. Table 4 lists the intrinsic 6-cm powers and the angular sizes for the highest resolution, highest sensitivity radio observations we are aware of for each of the 17 NLS1 galaxies listed by Goodrich (1989). Where the radio data were acquired at another wavelength, the flux densities were converted to 6 cm using a spectral index of $\alpha = 0.7$. The upper limit quoted for Mrk 359 comes from observations at 11 and 18 cm employing a 275-km interferometer baseline (Norris *et al.* 1990), and is a factor of three smaller than the limit found from single-dish observations by Dressel & Condon (1978).

It is possible to make rough comparisons of the radio properties of NLS1 galaxies with those of other Seyfert galaxies, but such comparisons are hampered by the fact that the sample of NLS1 galaxies is fairly small and is not selected by any uniform set of criteria. The distribution of radio luminosities at 6 cm is displayed in Figure 2. We have not derived a radio luminosity function because of the incompleteness of our sample. However, the range of radio luminosities, roughly 10^{20}- 10^{23} W Hz^{-1} at 6 cm, is well within the range typical of other Seyfert galaxies (e.g., Fig. 11 of Ulvestad & Wilson 1989).

Only nine NLS1 galaxies have been detected at centimeter wavelengths, and only four of those have measured angular sizes rather than upper limits. Therefore, deriving a formal radio size distribution is meaningless. However, the median radio size of the nine detected objects can be seen from Table 4 to be no larger than 260 pc. Converting previous results to a common Hubble parameter of 75 km s^{-1} Mpc^{-1}, median sizes have been found to be less than 170 pc for Seyfert 1.8 and 1.9 galaxies (Table 3 of Ulvestad 1986), and about 350 pc for a distance-limited sample of Seyfert galaxies of all classes (rl'able 10 of Ulvestad & Wilson 1989). Therefore, the radio data are consistent with the NLS1 galaxies having radio sources with sizes similar to those in the nuclei of other Seyfert galaxies. No more definitive conclusion can be reached because of selection effects, the small sample sire, and the effects of limited dynamic range. In this context, it should be noted that some apparently unresolved Seyfert-galaxy radio sources turn out to have sizes of a kiloparsec or more when mapped with higher dynamic range or better sensitivity to features having lower surf rface brightness (e.g., NGC 5506, Wehrle & Morris 1987; NGC 3516, Miyaji, Wilson, & Pérez-Fournon 1992).

One purpose of this investigation was to compare the innermost radio position angles with the polarization position angles of the NLS1 galaxies. However, the observations reported here resolved only Mrk 766, confirming earlier reports that the radio axis is oriented approximately perpendicular to the optical polarization position angle. This is also the case for Mrk 1126, as previously reported by Goodrich (1989). In contrast to Mrk 766 and Mrk 1126, the apparent position angle of the innermost radio axis of Mrk 957 in the map of Antonucci (1985) appears to be ~ 50°, nearly parallel to the optical polarization position angle of 43° found by Goodrich (1989). Unfortunately, a sample of three galaxies is not adequate to attempt any statistical tests of polarization alignments.

There is no obvious trend for the radio *power* to correlate with the percentage polarization of the optical continuum in the NLS1 galaxies. Although three of the five detected NLS1 galaxies with 6-cm powers above 10 22 W 117, ‘1 show significant optical polarization, so does Mrk 1126, the intrinsically weakest detected radio source listed in ‘l’able 4.

5. CONCLUSION

We have used the A configuration of the VLA to observe eight Seyfert galaxies, including seven NISI galaxies and one high-ionization Seyfert 2 galaxy. Two objects were observed only at 6 cm and were undetected, while the remaining six galaxies were detected by observations at various combinations of 3.6, 6, and 20 cm. Of these six galaxies, only Mrk 766 was barely resolved, while the others remain unresolved on linear scales generally ranging from 100 to a few hundred parsecs. Radio powers of NLS1 galaxies arc typical of those found previously in other Seyfert galaxies. The limited data on nine NLS1 galaxies detected using the VLA indicates that their radio sires are similar to those in other Seyfert galaxies, but no statistical statement can be made. Of the six NLS1 galaxies with significant optical continuum polarization, two have radio sources with axes roughly perpendicular to the polarization, while one may have a radio source parallel to the optical polarization, and the other three remain unresolved. The three unresolved sources with significant optical polarization are strong enough so that their radio position angles could be investigated at yet higher resolution by using VLA observations with longer integration times at shorter wavelengths or (perhaps) by using MERLIN.

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TABLE 1

OBSERVATIONS OF INDIVIDUAL GALAXIES

GALAXY	DATE	λ (cm)	TIME (MIN.)	BEAM
Mrk 42	1987JUL31	G	30	0".43 x 0".38, P.A. 54°
Mrk 493	1987AUG01	6	30	0".61 x 0".25, P.A. 12°
Mrk .507	1987 AUG01	20	12	1" 68 x 0".82, P.A.]8°
Mrk 684	1987JUL31	6	30	0".33 x 0".33, P.A. 0°
Mrk 766	1987 JUL31	2	25	Poor weather
Mrk 766	1991JUL15	3.6	48	0".19 x 0".18, P.A. 2°
Mrk 766	1987JUL31	G	20	0".42 x 0".39, P.A. 53°
Mrk 1239	1991JUL15	3.6	48	0".24 x 0".'21, P.A.165°
Mrk 1239	1987JUL31	6	30	0".39 x 0".38, P.A. 41°
Mrk 1239	1987JUL31	20	12	1".51 x 1".39, P.A. 21°
Mrk 1388	1987 AUG01	6	27	0".40 x 0".34, P.A. 177°
Mrk 1388	1987JUL31	20	12	1".24 X 1".22, P.A.19°
IRAS 1509–211	1991JUL15	3.6	48	O" 29 X 0".19, P.A. 158°
IRAS 1509-211	1987 AUG01	G	30	1".70 x 0".24, P.A. 1°
IRAS 1509–211	1987 AUG01	20	12	5".53 x 0".87, P. A. 178°

TABLE 2

VLA OBSERVING PARAMETERS

λ	FREQUENCY	BANDWIDTH	3C 286
cm	MHz	MHz	Jy
2	14940	00	3.41
3.6	8440	00	5.27
6	4860	100	7.43
20	1490	100	14.38

TABLE 3

RESULTS OF VLA OBSERVATIONS

GALAXY	z	R.A.	DEC.	λ	S_ν	log(P)	DIAM
		h m s	° ′ ″	cm	mJy	W Hz^{-1}	pc
Mrk 42	0.0260	11 51 05.716	462923.89	6	< 0.25	<20.51	. . .
Mrk 493	0.0314	15 5716,311	35 10 15.07	6	0.7740.16	21.16	< '260
Mrk 507	0.0546	174855.696	684305.55	.20	3.2140.37	22.26	< 1320
Mrk 684	0.0451	142853.1	283029.	6	< 0.25	< 20.99	. . .
Mrk 766	0.0121	121555.636	300525.57	3.6	7.26±0.46	21.31	60
Mrk 766	0.0121	121555.640	300525.57	6	11.70±0.63	21.52	60
Mrk 1239	0.0193	094946.287	- 01 2236.02	3.6	7.914.0.45	21.75	< 80
Mrk 1239	0.0193	094946.283	-01 2235.93	6	19.4941.05	22.14	< 140
Mrk 1239	0.0193	094946.280	-012236.02	20	56.50±2.84	22.61	<.540
Mrk 1388	0.0212	144823.036	225623.70	6	3.5040.29	21.48	< 150
Mrk 1388	0.0212	144823.031	225623.74	20	9.1140.48	21.89	< 510
IRAS 1509--211	0.0441	150906.854	--21 0746.27	3.6	6.90±0.47	22.38	< 210
IRAS 1509--211	0.0441	150906.861	-210746.28	6	12.1230,65	22.65	< 830
IRAS 1509-211	0.0441	150906.855	-21 0747.57	20	42.6132.16	23,20	< 2740

TABLE 4

INTRINSIC 6-CM RADIO PROPERTIES OF NLS1 GALAXIES

GALAXY	log(P) W Hz^{-1}	DIAM pc	REF
Mrk 42	< 20.51	...	1
Mrk 291	< 21.68	...	2
Mrk 359	< 21.30	...	3
Mrk 493	21.16	< 260	1
Mrk 507	21.90	< 1320	1
Mrk 684	< 20.99	...	1
Mrk 766	21.52	“ 60	1
Mrk 783	22.47	< 250	4
Mrk 9.57	22.16	~ 1400	5
Mrk 1044	<22.23	...	6
Mrk 1126	20.64	400	7
Mrk 1239	22,14	< 140	1
Akn 564	22.09	300	8
IRAS 1509–211	22.65	< 830	1
1747.346836	< 21.60	...	9
NGC 4748	...	...	...
PG 10164336	...	...	...

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FIGURE CA1'TIONS

FIG . 1. VLA image of Mrk 766 at 3.6 cm. Co ntour levels are separated by $2^{1/3}$, beginning at 0.27 mJy. The peak flux density is 3..53 mJy.

FI G. 2. IIistogram of 6-cm radio luminosities of the 14 NLS1 galaxies with published IIigll-sensitivity observations. Upper limits are denoted by hatching.

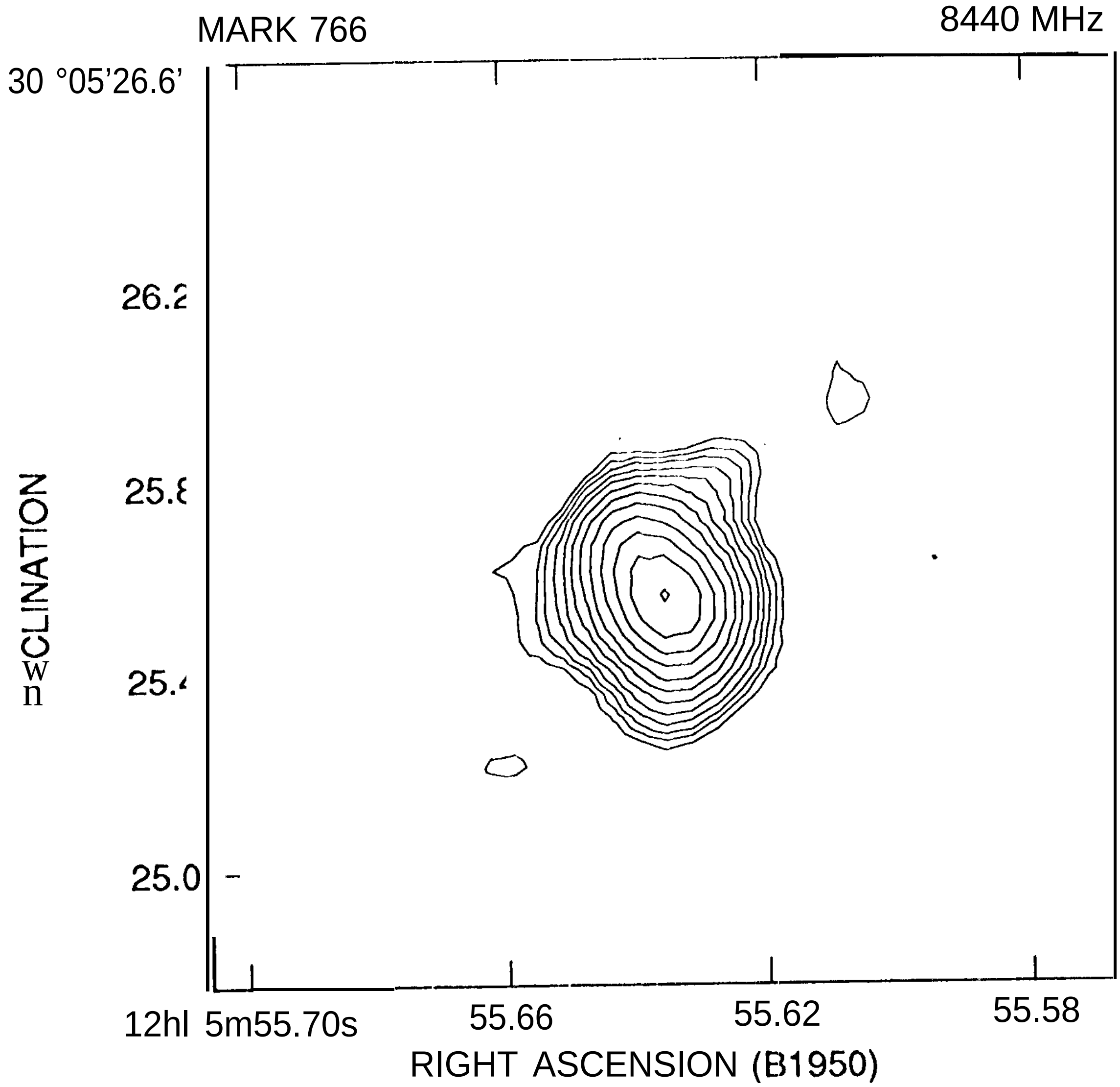
MARK 766
8440 MHz
30 °05'26.6'
26.2
25.8
25.4
25.0
DECLINATION
12h15m55.70s
55.66
55.62
55.58
RIGHT ASCENSION (B1950)

Figure 1

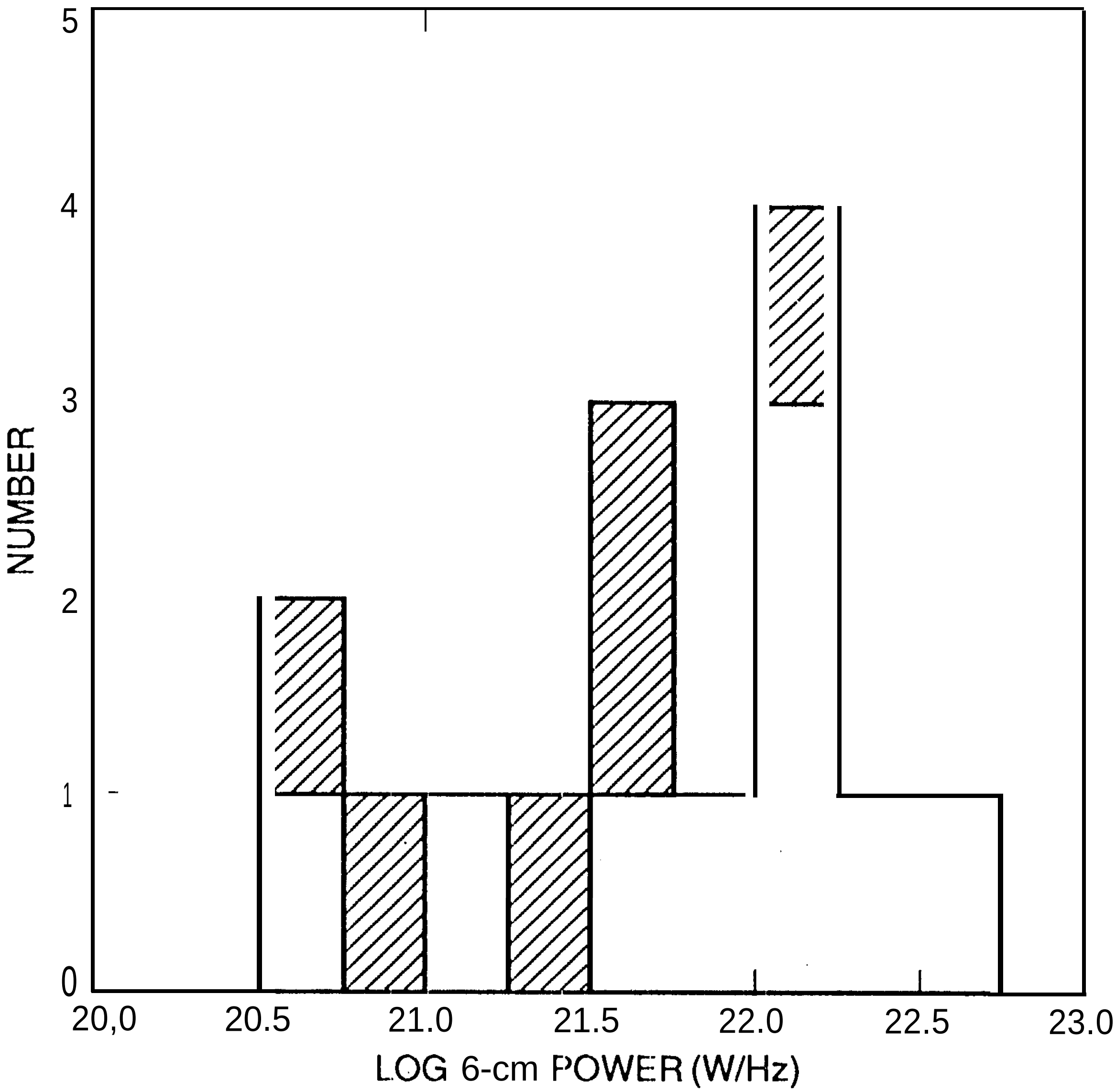

Figure 2